AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.

1791 Tullie Circle, NE Atlanta, GA 30329 404-636-8400

TC/TG/TRG MINUTES COVER SHEET

(Minutes of all meetings are to be distributed to all persons listed below within 60 days following the meeting.)

TC/TG/TRG NO. TC4.11 DATE: December 19, 2002

TC/TG/TRG TITLE: Smart Building Systems

DATE OF MEETING: June 25, 2002 LOCATION: Honolulu

Members Present	Appt	Members Absent	Appt	Ex-Officio Members and Additional Attendance
Les Norford, Chair (V)	02-	Arthur Dexter, International member (V)	99-	Osman Ahmed
John House, Vice Chair, Research Subc (V)	01-03	Carlos Haiad, (V)	00-04	Peter Armstrong
Michael Kintner-Meyer, Communications and Integration Subc (V)	99-03	Srinivas Katipamula (V)	01-05	Jim Butler
Todd Rossi, Fault Detection Diagnostics Subc, (V)	99-03	Steve Blanc, (V)	99-	Peter Gruber
Natascha Castro, Secretary, Web Master (V)	01-04	Rich Hackner, (V)	96-	Keith Temple

Barry Bridges (V)	99-03	Brian Kammers, CM	98-	Peng Xu
James W. Gartner (V)	02-	Ron Nelson, CM	99-	Don Aymann
Phil Haves, (V)	02-	Barry Reardon, CM	01-	Jon Douglas
John Seem, (V)	01-05	Dave Branson, CM	01-	Tim Salsbury
Mike Brambly, Testing and Evaluation Subc, CM	99-03	James Braun, CM	00-	Par Carling
Carol Lomonaco, , CM Program Subc	01-	Hung Mahn Pham, CM	00-	Rodney Martin
Agami Reddy, CM	01-05	Robert Old, CM	01-05	Virgil Seribo
John Mitchell , CM	01-	Charles Culp, CM		Hofu Kiu
George Kelly, CM	01-	David Kahn, CM	00-	Gene Strehlow
		Michael Brandemuehl, CM	00-	Song Zhang
		Thomas Engbring, CM	96-	David Shipley
				Kirstin Heinemeier
				Paul Reimer

				Glenn Remington
				Zach Obert
				Curtis Klaassen
				Pornsak Songkakul

(V) = voting member, Membership status as of 9/01

DISTRIBUTION:

ALL MEMBERS AND CORRESPONDING MEMBERS OF TC/TG/TRG,

TAC CHAIR: Edward Gut

TAC SECTION HEAD: Eckhard Groll

ALL COMMITTEE LIASONS AS SHOWN ON TC/TG/TRG ROSTERS:

Program: Emil E. Friberg Manager Of Technical Services: Martin J. Weiland

Research: Sheila Hayter Manager Of Research: William W. Seaton

Standards: David Knebel Manager Of Standards: Claire B. Ramspeck

Journal: Chad Dorgan Special Publications: Joseph Driscoll

TEGA: William Knight

ADDITIONAL DISTRIBUTION: Visitors listed above

ASHRAE TC ACTIVITIES SHEET

DATE: 24 July 2002

TC NO. TC4.11 TC TITLE: Smart Building Systems

CHAIR: Les Norford VICE CHAIR: John House

TC Meeting Schedule

Location, past 12 mo.	Date	Location, next 12 mo.	Date
Atlantic City	1/15/02	Chicago	1/28/03
Honolulu	6/25/02	Kansas City	6/24/03

TC Subcommittees

Subcommittee	Chair
Fault Detection and Diagnostics	T. Rossi
Utility EMCS	M. Kintner-Meyer
Testing and Evaluation	M. Brambley
Research	J. House
Program	C. Lomonaco

Research Projects

1043-RP Fault Detection and Diagnostic Requirements and Evaluation Tools for Chillers

1139-RP Development and Comparison of On-Line Model Training Techniques for Model-Based FDD Methods Applied to Vapor Compression Equipment

Long Range Research Plan (as approved by TC 4.11 at the Cincinnati Annual Meeting)

Rank	Title	RTAR Written	RTAR Approved	W/S Written	TC Approved	To RAC ?
1	Evaluation and Assessment of Fault Detection and Diagnostic Methods for Centrifugal Chillers – Phase II	Yes	9/00	Yes	Yes	No
2	Field Performance Assessment of Package Equipment to Quantify the Need for Monitoring, FDD, and Continuous Commissioning	Yes	No	Yes (3^{rd} draft)	No	No
3	Method of Testing FDD Tools for AHU's (was Benchmarking of FDD Tools for AHU's)	Yes	No[1]	No	No	No
4	Smart Sensor Systems for Reducing Measurement Errors in AC Systems (was Development of Fault Detection and Diagnostics for Sensor Failures)	Yes	No	Yes (1^{st} draft)	No	No
5	Concept of Self-Configuring Control Systems	Yes	No	No	No	No

6	Prototyping and Field Testing of Utility – Consumer Information Services	Yes	No	Yes	No	No
7	Resolving Discrepancies Between Multiple, Hierarchically-Related, Fault Detection and Diagnostic Systems	Yes	No	Yes	No	No

Technical Papers from Sponsored Research

Final report for ASHRAE Research Project RP-1011, "Utility/Energy Management and Control Systems (EMCS) Communication Protocol Requirements" is available on the TC 4.11 web site.

Results from the ASHRAE Research Project RP-1139, " Development and Comparison of On-Line Model Training Techniques for Model-Based FDD Methods Applied to Vapor Compression Equipment " have been published in the January 2001 issue of HVAC Journal.

Final report for ASHRAE Research Project RP-1043, " Fault Detection and Diagnostic Requirements and Evaluation Tools for Chillers" is available on the TC 4.11 web site.

Technical paper from 1043-RP, Comstock, M.C., Braun, J.E., and Groll, E.A., "The Sensitivity of Chiller

Performance to Common Faults," International Journal of Heating, Ventilating, Air-Conditioning and Refrigerating Research, Vol. 7, No. 3, pp. 263-279, 2001.

Technical paper from 1043-RP, Comstock, M.C., Braun, J.E., and Groll, E.A., "A Survey of Common Faults for Chillers," ASHRAE Transactions, Vol. 108, Pt. 1, 2002.

TC Sponsored Symposia (past 3 years, present, planned)

Title	Date (Given or Planned)
Recent Results from Fault Detection and Diagnostic Research (Norford)	Atlanta, 1/01
HVAC Diagnostics: Development to Implementation Part 1 (House)	Atlantic City, 1/02
HVAC Diagnostics: Development to Implementation Part 2 (Dexter)	Atlantic City, 1/02
FDD in HVAC Applications (Kelly, TC 1.4 cosponsor)	Kansas City

TC Sponsored Seminars (past 3 years, present, planned)

Title	Date (Given or Planned)
Practical Experience Using DDC Systems for HVAC Commissioning and Continuing Evaluation (Bridges; TC1.4 lead with TC1.7, TC4.11 and TC9.9 as co-sponsors	Dallas, 2/00
Deregulation for Dummies (Haiad)	Dallas, 2/00
Evaluating the Benefits of Fault Detection and Diagnostics	Dallas, 2/00

Providing for the Most Important Part of a Smart Building Control System: People (Bridges)	Minneapolis, 6/00
Control Systems Integration, What's Happening with Practical Open-Architecture Solutions (TC 4.11 co-sponsor)	Minneapolis, 6/00
Deregulation and Energy Efficiency in the State of California (Haiad)	Minneapolis, 6/00
Diagnostics from an Operations Perspective, Needs and Experiences (Rossi)	Atlanta, 1/01
Adding New Life to Old System-Control Retrofit Case Studies (TC 1.4 lead)	Atlanta, 1/01
Maximizing Facility Performance with Computerization and Controls (Gartner)	Cincinnati, 6/01
Data Modeling for Building Operations (Kintner-Meyer)	Cincinnati, 6/01
BACnet Manufacturers Association (BMA)- New role in Testing Interoperability of BACnet Systems (Newman)	Cincinnati, 6/01
Wireless DDC Systems (TC 1.4, Bridges lead)	Cincinnati, 6/01
Intelligent Agents What They Can Do For You (Ahmed)	Honolulu
Self-Configuring Control Systems: What are the Potential Benefits? (TC 4.6 co-sponsor)	Honolulu
Experience with Demand Responsiveness Program (Kintner-Meyer)	Honolulu

Automated HVAC Functional Testing for HVAC Systems (Haves, TC 4.6, 1.4 cosponsor)	Chicago
Wireless Sensors (Healy, TC 1.4 cosponsor)	Chicago
FDD from an Operator's Perspective (Rossi)	Future

TC Sponsored Forums (past 3 years, present, planned)

Title	**Date (Given or Planned)**
Specifying Open Lonmark DDC Systems	Atlantic City, 1/02
What Should ASHRAE's Role be in IFC and XML Standards (Gowri, GPC20 and TC 1.5 cosponsor)	Chicago 1/03
Addressing the Need for Data Modeling Beyond Building Design- What Role Should ASHRAE Play	Future
New Sensor Technology, Other New Technologies (Kintner-Meyer)	Future

TC Sponsored Public Sessions (past 3 years, present, planned): None

Journal Publications (past 3 years, present, planned): None

Minutes summary and activities sheet submitted by: Natascha Castro, TC 4.11 Secretary

TC 4.11 Minutes

Honolulu: July 25, 2002

Call to Order, Roll Call, Introductions

The meeting was called to order at 3:30 PM with Chairman Les Norford presiding. A roll call showed that a quorum was present. In attendance at the meeting were Norford, House, Kintner-Meyer, Rossi, Castro, Bridges, Gartner, Haves, Seem. Nine of 14 voting members were present.

Norford distributed the minutes from the Atlantic City meeting, the Agenda, and the revised scope and organization of the committee (the call-to-meeting letter and the agenda are in Appendix A)

Approval of Minutes

The minutes of the last meeting were reviewed. Norford requested comments for minutes submitted from Atlanta meeting. Minor corrections were made to the member list.

Motion 1: Motion to accept minutes from the January 2002 meeting (Motion: Gartner, 2nd: Bridges)

Voice Vote, Motion passed

Announcements (Norford):

1. President of ASHRAE is sending a thank-you letter to attendee's employers for their participation. Norford distributed the sign-up sheet.
2. Announcement from section head:
   - Asked to provide liaison for the ASHRAE Learning Institute. Chair will assume that role by default if no one else requests that role.
   - Program review process to be 100% electronic in fall.
   - Website space to be available in fall for TC's with common format.

- Handbook Committee is working to address/improve the usefulness of handbook to members.

- Roster in 2003 to be transmitted electronically, 10% no email available, 50% email bounced back. Please go onsite to check your contact information

3. Roster changes

    - Bridges and Gartner and House to roll off
    - Welcome Reddy, Ahmed as voting members
    - Brambley to be Secretary for 1 year
    - Castro to Chair Testing and Evaluation Subcommittee

Norford then asked for updates from the subcommittee chairs.

Report from the Research Liaison (Sheila Hayter)

Hayter asked for the status of new RTARs and work statements and recommended that RTARs be given to her for comment prior to sending them to ASHRAE. Norford reported that the TC will have two RTARS submitted by the August deadline.

Technology Development Subcommittee (Rossi)

Rossi reported that there were two projects in this subcommittee that were just completed, 1139-RP and 1043-RP. And that the completion of 1139-RP leads to phase II of chiller – work statement was approved by RAC. House added that the work statement was 1 of 12 approved and that it was to be prioritized in the coming weeks. Funding will be provided according to prioritization and could go out to bid as early as this fall.

New ideas discussed in the subcommittee were:

1. wireless sensors- what problems they can solve, how the benefits could justify costs of sensors, how they can reorganize themselves into networks.
2. fdd for refrigeration applications (supermarkets, convenience stores), possible collaboration with other TC's. House spoke with 10.3 and 10.9, he reported that they suggested that 10.7 might be a better match.
3. start working on a document to assess what currently exists, Phil had suggested a review of other areas besides refrigeration, rather than jumping straight into a work statement development.

4. Geothermal, ground source heat pumps- commissioning and maintenance issues that could be addressed.
5. On-line optimization in buildings that could be incorporated into Smart Building Systems

New Program- Seminar on wireless sensors (Healy) for Chicago

The minutes of the subcommittee meeting are in Appendix C.

Communications and Integration Subcommittee (Kintner-Meyer)

Kintner-Meyer reported that the subcommittee discussed the first draft work statement on "Design and Testing of a Self-Configuration Concept for an HVAC Control System". Braun first suggested concept over a year ago and several people collaborated to develop the RTAR. Young and Kowri provided input to the first draft of the work statement which Kintner-Meyer wrote.

The work statement is aimed at addressing the problem of the time-consuming nature of configuring controllers, and the occurrence of cross wired devices. The emphasis lies on developing a concept that would couple devices that are on the network with automatically generated binding lists.

There are 4 tasks 1) to look at the current state of the art in self-configuring systems, 2) specifications of self-configuring concept capabilities, 3) design of a concept for an HVAC control system, and 4) testing the self-configuring concept.

Kintner-Meyer invited people to help him review the document and give suggestions. Haves reported that TC 1.4 had a request to align for this work statement and may have good input for comments. Norford asked Kintner-Meyer to contact Dave Underwood in TC 1.4.

Program ideas: there is a seminar scheduled for Wednesday in Honolulu.

No new program was planned at this meeting. There is a need to find out what controls companies have & need. Controls companies have the capability to do some of the binding operations discussed but may benefit from verification.

The minutes of the subcommittee meeting are in Appendix D.

Testing and Evaluation Subcommittee (Brambley)

Focused primarily on discussing draft work statement "Method of Test for Air-Handling Unit Fault Detection and Diagnostic Tools". It was suggested that it may be better to have the work focus on the development of enabling tools and underlying simulation method rather than to develop a method of test at this time. A suggestion was made that House prepared a revised RTAR since it is moving work in a direction different that the original RTAR.

House provided additional detail. He reported that the previous RTAR had been approved last fall but not prioritized. The work statement was designed to develop a simulation tool designed for testing and validating simulations and testing FDD tools, also performance metrics, then to bring together the two to develop a method of test for developers to validate their methods. It was perceived that it might be better to focus on the simulation part of the project to produce fault-free and fault data over a range of operating conditions and to get data to validate models. This would be similar to Phase 1 of the chiller project except geared for an AHU, and eliminating the survey of what are the important faults. The revised RTAR leaves out the section on the evaluation part. It was suggested that the general method of test for FDD tools could be better developed out of a standards committee or ASHRAE guideline committee.

1. Seem pointed out that it is important to separate the simulation of the system from the simulation of the controls because different controls companies have different control strategies. House said the intent is to have a modular system so that developers can extract whatever control strategy was put in and replace it with their own strategy. Seem also said that the simulation should run 100-1000 times faster than real time for it to be of use.

2. Haves suggested that 825-RP, a project for TC 1.4 be mentioned in the background section.

3. Wright brought up the question of whether it is necessary to have blind faults. House stated that without the method of test it may not be possible at this point. Haves suggested a fault generation capability.

House requested comments by July 15th.

The minutes of the subcommittee meeting are in Appendix E.

Research Subcommittee (House)

House distributed a one-page list of all research activities and stated that a prioritized research plan had to be submitted to ASHRAE headquarters by August 1.

The first item on the list, the Phase II "Evaluation and Assessment of Fault Detection and Diagnostic Methods for Centrifugal Chillers" was accepted by RAC and is awaiting prioritization.

The second work statement "Field Performance Assessment of Packaged Equipment to Quantify the need for Monitoring, FDD, and Continuous Commissioning" was returned by RAC. Comments were minor:

1. There is only 1 author, will he be a bidder (the answer is no)
2. Shorten the title

3. Need a letter of support from DOE to show a commitment of funds. (Rossi reported that DOE cannot provide a firm commitment for funds, but can provide a letter of intent. May need to have a contingency plan if the 25K contract falls through. Rossi will try to get letter.)
4. Feeling that cost may be low. (Rossi provided a brief description of the work statement and background on the number of units selected for testing and the subset for servicing. Rossi addressed the cost, stating that the cost was not to cover the whole effort, but rather to subsidize the additional cost of testing and documentation. Rossi to add a note that this is supposed to piggy-back on normal service work)
5. Citations of studies in task 1. (Rossi to add citations)

Norford raised the issue of contractors correcting problems found, at the time they are found, rather than collecting data and letting a decision be made about what is repaired. Rossi stated that based on the size of the fault/expense of the repair there will be more time to evaluate

A vote to approve the revised work statement will have to take place before it can go to RAC. Les stated comments are minor and relatively minor to address and he does not feel it is necessary to wait until to Chicago to vote. Revised work statement can be submitted by September 6th for consideration in the fall.

Brambley raised issue that the sample size selected will not permit us to extract statistically significant quantitative information on the effectiveness of individual service actions. Rossi confirmed that this has been addressed in the work statement. Young stated that it could be possible to select faults to have a statistically significant sample size.

Phil proposed reviewing comments and planned responses

Motion 2: Motion to approve the work statement amended as discussed with a letter as can be obtained from DOE (Motion: Haves, 2nd: Gartner)

Discussion: Brandemuehl stated that there might be a problem to approve the statement without changes made. Les reported that cover sheet would be noted to reflect that. This is co-sponsored by 9.9 and therefore they will need to do a letter ballot.

Vote: For: 8 (CNV)

Against: 0

Abstain: 0

Motion passed

House presented status of other proposed research, existing and new, which are listed in the long range research plan on the TC Activities sheet above. New ideas included FDD for Supermarket Refrigeration, On-line Optimization in Buildings, and Whole building FDD.

House suggested that any interested parties contact the champion to make contributions to write RTARs or work statements.

Motion 3: Motion to approve the research plan as provided with the first priority being "Tools for Evaluating FDD Methods for AHUs" and the second priority being "Design and Testing of Self-Configuration Concepts for an HVAC Control System" (Motion: House, 2nd: Rossi)

Discussion: approved RTAR for "Tools for Evaluating FDD Methods for AHUs", but since scope has changed, it is to be resubmitted. These proposed 2 priorities are furthest along. Gartner asked whether the Wednesday seminar would feed into the work statement for "Design and Testing of Self-Configuration Concepts for an HVAC Control System" as well as comments from TC 1.4. Norford stated that if not completed by Chicago, the work statement could be submitted for Kansas City and in either case we will have had at least a year to develop a strong work statement out of the approved RTAR.

Vote: For: 8 (CNV)

Against: 0

Abstain: 0

Motion passed

House reported on information from the Research Chair's breakfast meeting. He raised concern that because ASHRAE charges for electronic versions of RP final reports, we need to have permission for posting this on our website. This issue was discussed and it was believed that ASHRAE charges for the processing costs, not to seek profit on it.

House reported on information from the section 4 breakfast meeting. Research and TC chairs are working to develop a strategic plan for research to take better advantage of research dollars, and that handbook is too heavy on technology and less practical information.

1. Les to draft a scope for section four.
2. We will also be sharing RTARs and long-range research plans to get some reviews and also to find areas for joint projects.
3. Haves has been involved in forging greater alliances for TC's interested in the operations side of buildings (TC 1.4, 1.7, 4.6, 9.9…).

Haves added that the strategic plan at society level should have input from our TC.

4. There is a project to design a test building based solely on the handbook, thereby highlighting the gaps in the handbooks. TC's of section 4 are championing this proposal which could lead to the development of a design manual.

House stated that last 45 min of research discussions- brainstorming, therefore greater participation is encouraged.

The minutes of the subcommittee meeting are in Appendix E.

Program Subcommittee (Lomonaco)

Lomonaco reminded that two seminars are scheduled for Wednesday and one co-sponsored with TC 4.6.

Program for Chicago:

1) Seminar, Haves "Automated Functional Testing For HVAC Systems", Cosponsor 4.6 and 1.4

2) Forum, Gowri "What Should ASHRAE's Role be in IFC and XML Standards"GPC20, TC 1.5 (Krishnan Gowri to coordinate with GPC, to go to 1.5 program to make sure they are in agreement)

3) Seminar, Healy "Wireless Sensors" Cosponsor 1.4

Program for Kansas City:

1)Symposium, Kelly, "FDD in HVAC Applications" Cosponsor 1.4 (papers House, Haves, PNNL, package due Feb 7)

Future:

Seminar, Rossi "FDD From An Operator's Perspective."

Forum, Kintner-Meyer "Addressing The Need For Data Modeling Beyond Building Design, What Role Should ASHRAE Play"

Forum, Kintner-Meyer "New Sensor Technology, Other New Technologies"

Motion 4: Motion to approve the program as provided with the following priority: 1)Seminar, Haves "Automated Functional Testing For HVAC Systems", Cosponsor 4.6 and 1.4, 2)Forum, Gowri "What Should ASHRAE's Role Be In IFC and XML Standards"GPC20, TC 1.5, and 3) Seminar, Healy "Wireless Sensors" Cosponsor 1.4. (Bridges, Gartner, 2nd)

Vote: For: 8 (CNV)

Against: 0

Abstain: 0

Motion passed

Co-sponsorship:

TC 1.4, seminar, Atkinson "New Issues In State of the Art DDC Systems, Part B"

TC 1.4, seminar, Coogan "DC Actuators"

TC 1.4, cosponsor TC 9.1, seminar, Shadpour, "New Control Strategies For Variable Flow Chilled Water Systems"

TC 1.4, cosponsor TC 1.5 Forum, Kahn "How Should the Handbook Cover Network Technology"

TC 1.4 Forum, Pouchak "Specifying Open Lonmark DDC Systems.

Motion 5: Motion to approve the program co-sponsorship as listed above. (Kintner-Meyer, Gartner, 2nd)

Voice vote approved.

Motion passed

Brambley reminded that rejected program does not need to be resubmitted, though any updates for co-sponsorship must be resubmitted. Only a note to the Program Committee requesting consideration of the session package for the next meeting is needed.

Programs as subsequently approved by ASHRAE are tabulated at the beginning of these minutes.

Handbook

No handbook report.

Web-site

Presentation slides should be submitted to Natascha Castro for Seminars and Symposiums.

Old Business

No old business

New business

Les will contact Chairs in other committees to share work statements with research chairs.

Vern Smith AEC to maintain list (list server). Burnside to look into use of list server.

Adjournment

At 6:40 p.m.

Motion 8: Motion to adjourn (Motion: House**, 2nd: Kintner-Meyer)**

Vote: Unanimous

Motion Passed

Appendices

A. Call to Meeting and Agenda
B. Scope and Organization
C. Technology Development Subcommittee Report
D. Communications and Integration Subcommittee Report
E. Testing and Evaluation Subcommittee Report
F. TC4.11 Research Subcommittee meeting/Planning Session
G. Research Plan and Activities
H. List of Subcommittee Attendees

Appendix A.

Call to Meeting and Agenda

ASHRAE American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

1791 Tullie Circle, NE, Atlanta, Georgia 30329-2305 404-636-8400 | Fax 404-321-5478

Reply to: Les Norford

Room 5-418

MIT

77 Mass. Ave.

Cambridge, MA 02139

lnorford@mit.edu

June 14, 2002

Dear TC 4.11 Member, International Member, or Corresponding Member:

The **TC** on Smart Building Systems and its subcommittees will meet in the Hawaii Convention Center, Honolulu, according to the following schedule:

TC 4.11 Tech. Development Sunday (1/13) 3:00-3:45p HCC/325B

TC 4.11 Comm. & Integration Sunday (1/13) 3:45-4:30p HCC/325B

TC 4.11 Testing & Evaluation Sunday (1/13) 4:30-5:15p HCC/325B

TC 4.11 Research Sunday (1/13) 5:15-6:00p HCC/325B

TC 4.11 Smart Building Systems Tuesday (1/15**) 3:30-6:00p HCC/323A**

The TC is the co-sponsor, with TC 1.4, of the following program sessions in Honolulu, which will be held in the Hilton Hawaiian Village:

Seminar 36: Self-Configuring Control Systems: Technology and Potential Benefits

Wednesday, June 26, 2002, 8:00 AM –10:00 AM, South Pacific 1, Chair: Michael Brambley

Seminar 41. Intelligent Agents - What Can They Do for Your Building?

Wednesday, June 26, 2002, 10:15 Am – 12:15 PM, Coral 4, Chair: Osman Ahmed

Please see the ASHRAE Program Booklet to confirm session locations and times.

Attached is a draft agenda for the full TC 4.11 committee meeting in Atlantic City. I hope to see you all there.

Les Norford

Chairman, TC 4.11

ASHRAE TC 4.11, Smart Building Systems

2002 Annual Meeting, Honolulu

AGENDA

Location: Room 323A, Hawaii Convention Center

Date: Tuesday, January 25, 2002

Time: 3:30 - 6:00 p.m.

1. Roll call and introductions

2. Approval of Minutes from Atlantic City

3. Announcements

- TC roster for 2003

4. Technology Development Subcommittee Report (Todd Rossi)

- Summary of draft work statements
  - Design and Demonstration of a Self-Configuration Concept for an HVAC Control System
  - Other
- Other activities

5. Communications and Integration Subcommittee Report (Michael Kintner-Meyer)

1. Summary of draft work statements
2. Other activities

6. Testing and Evaluation Subcommittee Report (Michael Brambley)

1. Summary of draft work statements
2. Method of Test of AHU FDD Tools
3. Other

2. Other activities

7. Research (John House)

- Status of submitted work statements
- Section 4 research-coordination meeting

1. Research roadmap
2. Long-range research plan

9. Program Subcommittee Report (Carol Lomonaco)

1. Plans for Chicago (1/25-29/2003) and Kansas City (6/28-7/1/2003)

10. Handbook (Les Norford)

1. Coordination with other TCs on issues related to building operation

11. TC 4.11 Website (Natascha Castro)

12. Old business

13. New business

14. Adjournment

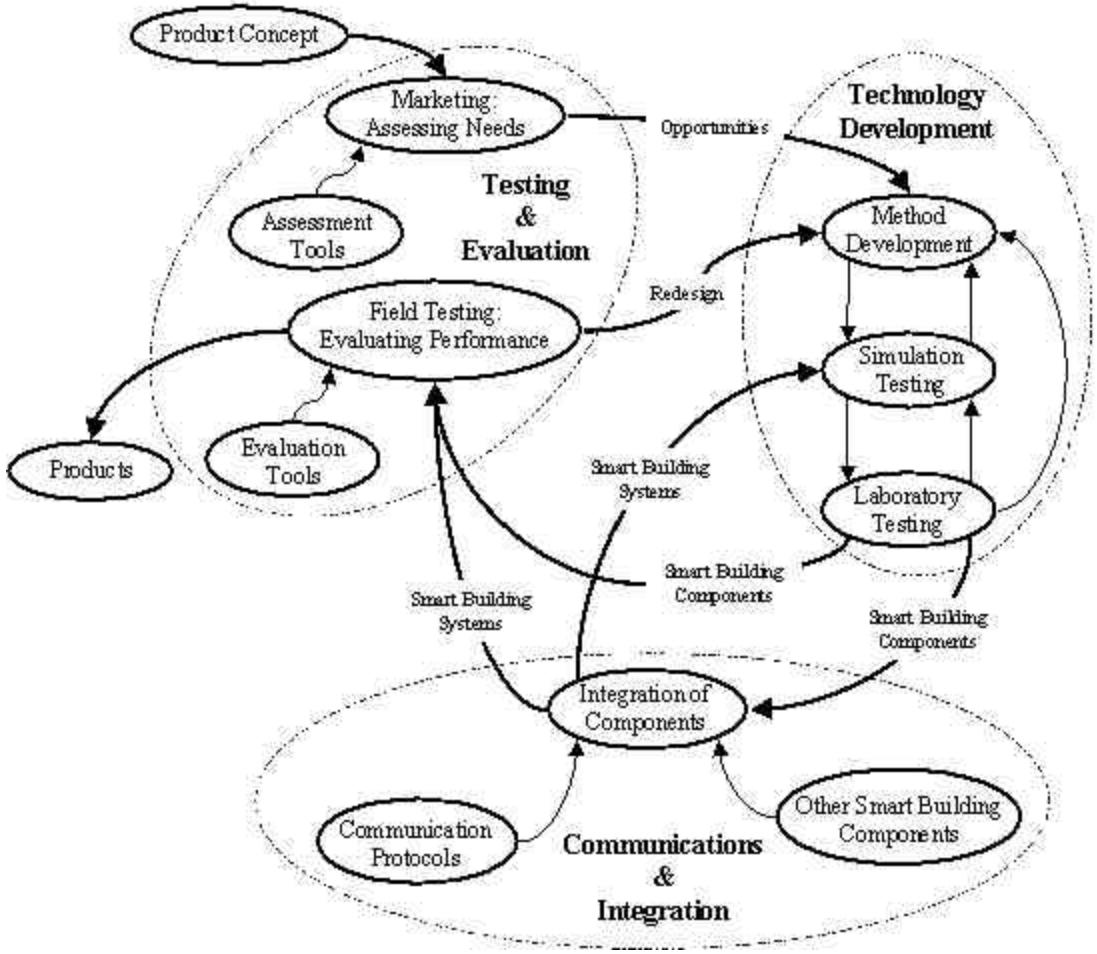
Appendix B.

TC 4.11, Smart Building Systems Scope and Organization

Revised July 1, 2001

Overall Committee Scope

The Technical Committee on Smart Building Systems (SBS), TC 4.11, is concerned with the development and evaluation of technologies that could enable the widespread application of smart building systems. "Smart" buildings should take advantage of automation, communications, and data analysis technologies in order to operate in the most cost-effective manner. This implies integration of building services such as HVAC, fire, security, and transportation; the automation of many of the operation and maintenance functions traditionally performed by humans; and the interaction with outside service providers such as utilities, energy providers, and aggregators. Currently, three subcommittees form the backbone of the TC's activities: technology development, communications and integration, and testing and evaluation. The scope and activities of these subcommittees loosely follow the product development process as depicted in following flow chart and as defined in the following sections.



Technology Development Subcommittee

Scope

The Technology Development Subcommittee is concerned with research issues associated with the development of emerging smart building technologies such as (but not restricted to) automated commissioning, performance monitoring, fault detection and diagnosis, optimal maintenance scheduling, and self-configuring control. The primary outcome of research endorsed by this subcommittee is expected to be data and models that enable development of the technologies and comprehensive methods that are the basis of the technologies. An integral part of the development

process is simulation and laboratory testing. Proposed designs must be tested and modified prior to field evaluation or integration with other smart building components.

Vision

The ever-increasing speed of organizational changes of the occupants in today's buildings demand greater flexibility of the building structure and the building automation system to respond to these changes. Furthermore, smart building systems offer the promise of dramatically improved building performance (e.g. comfort, reliability, and energy efficiency) and lower operating cost.

HVAC equipment automated commissioning, performance monitoring, fault detection and diagnostic, and optimal service scheduling technology directs service personnel to fix equipment problems causing poor comfort, reliability, and/or energy efficiency during different stages in building life cycles. Compared to the tools available today, these technologies are more sensitive to significant performance degradations, they are more aware of the entire building performance picture, and they help accomplish service tasks quicker.

Plug-and-play or self-configuring control systems are critical technologies needed to make buildings more flexible and to reduce the labor and expertise needed to install and maintain building automation systems. Self-configuring controllers understand their role in the building system. They are aware of the presence of other devices in the building and how they relate and interrelate with them to collectively provide building services. This high level of functionality is provided by highly skilled people at great cost today. When these people are freed for these tasks and costs are reduced, sophisticated building automation systems will become even more wide spread and the people will move on to even higher level tasks leading toward finely tuned and optimally performing buildings.

Research Agenda

To accomplish these broad goals, the subcommittee is focusing its near-term effort in the following directions:

1. Fault detection and diagnostic (FDD) technology focused on HVAC components like refrigeration cycles (including chillers, direct expansion cooling, and refrigeration) and air handing units.
2. Technologies supporting equipment FDD including smart sensor systems.
3. Self-configuring control systems

Research Projects

The sections below list ongoing (o) and planned (p) research related to the subcommittee's technology development goals. The subcommittee has no completed (c) or rejected (r) research projects. The studies are also shown on a timeline provided as a separate document.

o 1043-RP Fault Detection & Diagnostic Requirements & Evaluation Tools for Chillers – Purdue University was provided a no cost extension until the expected completion date on 6/31/01.

o 1139-RP Development and Comparison of On-line Model Training Techniques for Model-Based FDD Methods Applied to Vapor Compression Equipment – Drexel University was provided a no cost extension until the expected completion date on 8/31/01.

p Evaluation and Assessment of Fault Detection and Diagnostic Methods for Centrifugal Chillers – Phase II - Approved in Minneapolis and will submit to RAC AFTER Phase I (1043-RP) is completed. RTAR approved 9/00.

p Smart Sensor Systems for Reducing Measurement Errors in AC Systems - One page description exists. A two page version is being discussed and revised.

p Self-configuring Control Systems – RTAR+ document under development for Cincinnati.

There are three phases associated with this the chiller fault detection project. The first phase is an ongoing project (1043-RP) where the important faults are being considered and the appropriate sensors will be identified. In addition, a model for simulating chiller behavior is being developed that can be used to evaluate FDD performance for the different faults. The second phase is a planned research project where the FDD methods will be developed, implemented, and evaluated through simulation. This phase will produce a comparison of alternative FDD methods and recommendations for real-time implementation. Finally, the third phase will involve the real-time implementation and evaluation of FDD methods within the laboratory and the field. It is hoped that by the end of the third phase, an algorithm will be specified for incorporation within commercial products.

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Communications and Integration Subcommittee

Objective

The Communications and Integration Subcommittee is concerned with research issues associated with enabling the seamless interaction of smart building components and services within buildings, among buildings, or with an outside third party. An important aspect of this work is to identify the information that is necessary to support smart building technologies, and to identify the requirements of communication protocols to support the exchange of this information between different building services, between buildings and utilities, between multiple buildings, with outside service providers, etc. Another aspect of this work deals with the technical issues, challenges, and opportunities of integrating building systems to utilize synergies among the system components to achieve high performance building operation and highly productive work and living environments.

Addressing the Need for Innovative Building Automation Communications Systems and Services

Key to the high-performance operation and maintenance of a smart building system is the communication among various building system components that enables innovative control, monitoring and diagnostics concepts. The ever-increasing speed of organizational changes of the occupants in today's buildings demand greater flexibility of the building structure and the building automation system to respond to these changes. This will require highly flexible building automation system and a communication infrastructure to support the flexibility demanded.

Wireless sensors and control systems are emerging for building automation applications that provide a great opportunity to support and expand innovative and flexible control concepts to allow personalized and localized buildings control. As personalized and localized controls become reality, the number of sensors and control points in a building will grow significantly. This increase in sensor and control points will require a communication infrastructure that can re-configure itself to quickly establish connectivity to the added devices to the entire network. Plug-and-Play concepts are necessary for the rapid deployment of new sensors and control equipment with minimal or no set-up time.

The convergence of data and building automation networks will enable innovative remote building monitoring and control services. The need to reduce cost for the building operation will drive innovation for building remote monitoring, diagnostic, and control concepts. New building cooling, heating, and power technology and distributed power concepts will enable buildings to become zero-buyers of electricity or even net producers of electric power, whenever there is an economic incentive. To evaluate the economics of the trade-off between on-site electricity production and buying electric power from the service provider requires instant communications to the electricity markets to receive the hourly or sub-hourly changing price information. With these new technologies in place, the defining lines between the supply and demand sectors become increasingly blurred. Advanced load management strategies will seek optimal operation and dispatching of heating, cooling, and power system not only within the framework of a single building but also in a campus setting including many buildings. To engage in these new services, constant interactions among the energy consuming and producing must be in place. This will require information protocols and standards to support these services over wide-area networks.

Addressing the Need for Integration of Building Systems

The subcommittee addresses integration issues at three levels:

1. Integration of existing building automation functions (e.g., HVAC, lighting, fire alarm, safety and security systems)
2. Integration of advanced automated fault detection and diagnostic methods and tools into existing HVAC control systems
3. Integration of different automated fault detection and diagnostic tools to enhance each other's functionality and effectiveness.

Integration of existing building automation functions: Building control system in the past have been developed and deployed independently from each other to address a specific building need. HVAC, lighting, fire alarm, and safety systems emerged in their specific industries with a set of standards and safety requirements. To fully utilize cost savings opportunities the building control systems will need to be integrated into one building automation system. Integration will support not only the use of common communication infrastructure but also seek synergetic interactions that provide enhanced

functionality and value added.

Integration of advanced automated fault detection and diagnostic tools into existing HVAC controls: With the transition of automated fault detection and diagnostics tools from the research to the demonstration and deployment stage, the new tools need to be integrated into existing HVAC equipment control or building automation systems to share sensor and equipment information for the diagnosis.

Integration of different advanced fault detection and diagnostics tools into larger diagnostics systems. As more fault detection and diagnostics tools for HVAC equipment are being developed, it becomes increasingly important to harmonize the results of each diagnostic component in order to resolve discrepancies in the diagnosis and to seek internal corroboration and mutual substantiation of the same underlying problem. As the complexity of the HVAC fault detection and diagnostic system grows, it will be essential to maintain internal consistency among different diagnostic tools.

Near-Term Research Agenda of the Subcommittee:

To satisfy the science and technology needs mentioned above, the subcommittee will work on the following research topics:

1. Establish communication protocols that support automated data exchanges between service providers and buildings automation system to enhance energy efficiency, high performance of equipment operations and cost savings in buildings.
2. Promote plug-and-play and self-configuration concepts to avoid set-up problems of HVAC control systems.
3. Research the use of wireless sensors and controls for building operations and the integration into existing wired controls infrastructures.
4. Research integration opportunities to enhance the value of each single controls and diagnostics component.

The section below lists ongoing (o), planned (p), completed (c) and rejected (r) research related to the topics above.

(c) 1011-RP Utility/EMCS Communication Protocol Requirements – completed in summer 1999. The primary objectives of research project 1011-RP were: 1) to identify potential new information services that utilities or electricity suppliers are likely to offer to their customers, 2) to determine the communication and data requirements to establish these services, and 3) to develop data object models that support interoperability for the implementation of the services.

(p) Prototyping and Field Testing of ASHRAE's Utility Consumer Interface Models (UCIM) – A work statement has been written. This research is an extension of the completed 1011-RP project. ASHRAE proposes a project for prototyping and testing a set of selected information services defined in research project 1011-RP. The project focuses on the prototyping and testing of information services under lab conditions in

which the communicating parties are simulated. Co-sponsorship by SSPC 135 is sought.

(p) Resolving Discrepancies Between Multiple, Hierarchically-Related, Fault Detection and Diagnostic (FDD) Systems – A work statement has been developed. The proposed research will identify conditions in which two or more fault detection and diagnostic systems of may find disagreeing conclusions for the same underlying system faults. The research will identify solutions for resolving the discrepancies in the diagnostics provided by multiple fault detection and diagnostic systems.

(p) Self-Configuration of HVAC Control Networks – RTAR is being developed. The proposed research will describe novel self-configuration concepts used in data networking and personal computer technologies and analyze their applicability to HVAC control networks. Self-configuration methods in personal computer technologies have been proven to significantly reduce the set-up time and set-up errors. It is expected that similar advantages can be realized for when installing complex HVAC control networks in large buildings.

Testing and Evaluation Subcommittee

Objective

The Testing and Evaluation Subcommittee is concerned with research issues associated with assessing the benefits (market potential) and performance of smart building technologies such as fault detection and diagnostics, automated commissioning, self-configuring systems, etc. Research endorsed by this subcommittee is expected to result in data, metrics, methods, and tools/standards/guidelines for quantifying smart building system benefits and performance in a standardized manner, as well as findings from the actual application of these metrics, methods and tools. The sections below describe the goals of the subcommittee in more detail and list ongoing (o), planned (p), completed (c) and rejected (r) research related to these goals.

Assessing the Benefits of Smart Building Technologies

Research related to assessing the benefits of smart building technology can help define and justify research on such technology by establishing how (and by how much) the performance of existing technology can be improved. Successful studies of this nature can lay the groundwork for acceptance of new technology by end-users. To be successful and to gain support from ASHRAE, studies should be targeted at existing technology that is known to have performance problems. Furthermore, proposed studies should have a clear procedure and set of metrics (or at least such procedures and metrics should be perceivable at the start of the research) that will enable performance to be quantified in an objective manner (e.g., energy savings, time savings, etc.). In some cases a study may include demonstrations of prototype tools that can improve performance, while in other cases the study may be limited to measuring the performance of an existing technology, as new technology does not yet exist.

The status of studies related to assessing the benefits of smart building technology is summarized below. The studies are also shown on a timeline provided as a separate document.

1. **Integrated Control of Building Services**
   – RTAR was rejected by RAC and dropped from consideration by TC 4.11

1. **Field Performance Assessment of Packaged Equipment to Quantify the Need for Monitoring, FDD and Continuous Commissioning**
   – RTAR was rejected by RAC in the Fall of 2000 – a new version of the work statement is under development

Note that the second study cited above deals with field performance assessments of HVAC equipment. The outcome of this study should help establish the need for automated FDD and continuous commissioning. Studies aimed at field performance assessments of other equipment (e.g., chillers, fan coil units) may also be merited. At present, no research aimed at assessing the benefits of smart building technology have been identified for the focus areas of interconnectivity/interoperability and self-configuring systems. A proposed study in the area of integrated controls, services and facilities was rejected by RAC.

Assessing the Performance of Smart Building Technologies

Research related to assessing the performance of smart building technology is intended to produce data sets, metrics, protocols, etc. for quantifying performance, and/or to demonstrate and test specific smart building technology in pre-commercial stages of development. Successful studies will lead to tools that can be used to test the performance of smart building technology throughout its development cycle. Demonstration studies will help establish the potential of smart building technology while also identifying possible deficiencies in the demonstrated technology.

The status of studies related to assessing the performance of smart building technology is summarized below and on the timeline of the accompanying document.

1. **Demonstration of FDD Methods in a Real Building (1020-RP)**
   – completed 2/00

1. **Prototyping and Field Testing of Utility – Consumer Information Services**
   – championed by TC 4.11 Communication and Integration Subcommittee

2. **Method of Testing FDD Tools for AHU's**
   – existing work statement needs revision

3. **Evaluation and Assessment of FDD for Centrifugal Chillers – Phase III**
   – Phase II of this work is being championed by TC4.11 Technology Development Subcommittee and has not been initiated yet.

Note that the second study listed above is being championed by the Communication and Integration Subcommittee of TC 4.11; however, the testing work is closely related to the goals of this subcommittee. At present, no research aimed at assessing the performance of smart building technology have been identified for the focus areas of integrated controls, services, and facilities and self-configuring systems.

Appendix C.

TC4.11 Technology Development Subcommittee Meeting

Minutes

Honolulu, June 23, 2002 3:00-3:45 p.m.

Notes by: John House

Technology Development Subcommittee Meeting

Sunday, June 23, 2002

Todd Rossi welcomed everyone to the meeting.

Les Norford announced the phase II chiller project was approved by RAC. John House gave a summary of where it stood in the process. Haves indicated the society might have funds for up to 15 new projects this year.

Rossi announced that two projects were completed (1043-RP and 1139-RP) and asked for new research topics.

1. Wireless Sensors

Bill Healy expressed an interest in wireless, self-organizing networks of sensors. How do they talk to one another? Do they recognize the existence of a new sensor?

Mike Brambley indicated PNNL is looking at commercially available technologies, its applications, and its costs. Their interest is in reducing the cost. They have not looked at self-organizing networks.

Convenience of wireless is a primary benefit. Wired sensors may need conduit and the cost can be prohibitive. In such cases, wireless is cost effective.

Phil Haves indicated the commissioning industry might be a good application. Brambley indicated that Architectural Energy Corporation has some wireless technologies for use with their data loggers.

2. FDD for supermarkets

Rossi introduced the idea. The opportunity is there because of the costs for failures is large. Jim Braun indicated that Mike Brandemuehl has done some work in this area. The suggestion was made that we should coordinate with the appropriate TC for this application area. TCs 10.9, 10.7, and 10.3 might be appropriate.

Phil Haves suggested that we should consider doing a gap analysis for FDD. Supermarkets and chillers are good areas. What other application areas are not being addressed?

3. FDD for supermarket/convenience stores walk in coolers

Rossi introduced. Phil suggested that House talk with the Section 10 research chairs about this topic at the Monday Section Head meeting.

4. FDD for geothermal systems

Rossi introduced. External loops tend to get dirty.

Rossi also suggested that an article be written by the TC and disseminated to the society that would summarize needs in the area of FDD. Haves and Norford supported this idea. An article for the ASHRAE Journal or Transactions might be appropriate. It would have more credibility if it came from the TC and therefore useful in proposals. The article should examine what has been done, what is going on now, and what is needed.

Rossi asked if it should be narrowed (e.g., emphasis on refrigeration). Haves suggested a broader summary of all applications would be a better first

step.

Daryl Massey suggested we look at the automobile industry because they are so far ahead of the HVAC industry.

5. On-line optimization.

George Kelly suggested that on-line optimization would be another area of future research. Braun suggested it might be useful to go back and look at what it would take to implement optimization in an on-line sense within the overarching topic area of self-configuring systems.

1. (continued) Wireless Sensors Revisited

Brambley suggested we try to brainstorm on how self-organizing could be applied or could benefit our industry. Kelly suggested a seminar on this topic (wireless sensor technology for HVAC applications) would help generate interest and ideas. Healy will chair a seminar on the topic.

Appendix D.

TC4.11 Communications and Integration Subcommittee Meeting

Minutes

Honolulu, June 23, 2002 3:45-4:30 p.m.

Notes by: Michael Kintner-Meyer

TC 4.11 Integration and Communications Subcommittee meeting minutes

June 23, 2002

Chair: Michael Kintner-Meyer

Michael Kintner-Meyer provided a review of his work statement on Self Configuring controllers. Copies were distributed to all members.

George Kelly: Is test example specified well enough? MKM: Example assumes cooling only. Maybe some more specification is needed?

Massie: Are self-announcing sensors available? Is it possible?

Bob Old: There are many application-specific controllers available.

Michael Kintner-Meyer: There are self-tuning algorithms available. The novelty is the self-generated binding list.

Dave Branson: An important aspect is self healing when component goes offline. Is this in the scope of this project? The project should address this issue. An example might use redundant ambient sensors and watch the binding list change when one goes off line.

Mike Brambley: This work statement needs to be more focused, especially for $100K. Kelly agrees.

Phil Haves: Does this help promote interoperability? What is the unique advantage of ASHRAE doing this as opposed to in-house at a controls manufacturer?

Dave Underwood: Need results to apply to other vendor products in the same way.

David Chassin: BACnet is not ready to address these questions. Example: inform the role of the controller in the building. BACnet addresses the transport problem. Hard contribution: Recognize the installed topology of the building as opposed to the design. Watch cause and effect on control action to observed measurements. This is a valuable contribution.

Michael Kintner-Meyer: Controls vendors: Is this a valuable contribution? What configuring tools are available?

Clay Nessler: JCI proprietary configuration tool is being described on Wed. Clay supports David’s idea. This would be valuable for commissioning. This would solve a general problem.

Michael Kintner-Meyer: Commissioning tool. Run tests. See what worked and not. Steps: 1) get binding list 2) resolve ambiguities.

Michael Kintner-Meyer: Is this a niche problem or more global? Carol: Need to limit.

Bob Old: Binding is not such a big problem. Likes the idea of a system finding out wiring problems by itself over the weekend as described by David.

Mike Brambley: Define the systems or equipment to narrow scope.

John House: Is this automated functional testing: Brambley: Is it hooked up right? Does this need coordination to commissioning?

David Chassin: Sees this separate from commissioning. This is intended to help the control installed find problems before turning the process over to commissioning.

Mike Brambley: Not include 9.9, but 1.4? Commissioning is applied to broader issues. This is more focused than main line commissioning.

Michael Kintner-Meyer: Looking forward to support, feedback, and help, specially from those speakers on Wednesday, who will present on the topic of "Self-configuring systems and their benefits".

Mike Brambley: This work statement is currently far too general. Focusing it will resolve confusion.

Michael Kintner-Meyer: Program ideas? Wireless sensors are covered. Nothing else.

Appendix E.

TC4.11 Testing and Evaluation Subcommittee Meeting

Minutes

Honolulu, June 23, 2002 4:30-5:15 p.m.

Notes by:

Discussion of Work Statement on Evaluating FDD Needs for Rooftop Units

The status of the work statement on Evaluating FDD Needs for Rooftop units was briefly reviewed. It was reported that the RTAR was approved and prioritized. The work statement was returned, but comments were not provided yet. The committee needs to obtain these comments to determine the next step.

Discussion of Draft Work Statement on Method of Test for AHU FDD Tools

John House passed out a draft work statement on "Method of Test for AHU FDD Tools" and summarized the highlights of the work statement and its history. Desired hands off approach. A summary of key comments and discussion follow.

- John received feedback from Jonathan West and Agami Reddy before the meeting.
- George Kelly: This work is very similar to that completed in 1020. How can we apply our experience from that effort to this?
- John House: This would formalize the method.
- Les Norford: Very much not "hands off" approach for evaluation. Grad students did a lot of innovative work. This effort could be similar to Jim Braun's work statement effort in chiller FDD. This should add credibility to test results.
- Hashem Akbari: It's not clear who the ultimate user would be? Manufacturers, building operators, others? Also, the context in which the FDD would be used is important. Would the FDD be embedded in an EMCS?
- John House: The intent is not to develop a particular FDD tool, but to develop a testing tool, protocol, or procedure for developers to use to test how well their FDD tools work. The intent is to get ASHRAE credibility behind the test method.
- Jim Braun: It could lead to a standard.
- Hashem Akbari: The user group is controls manufacturers. This is a small group. Should ASHRAE membership fund development for this small group?
- Phil Haves: You could say that about almost any ASHRAE research. There has been slow uptake of these systems. This work could help eliminate one of the barriers to use of this technology.
- Jim Braun and George Kelly: This effort helps lower barriers and set standards. That is appropriate for ASHRAE.
- Hashem Akbari: The user and the hardware are still important.
- Agami Reddy: We need to have some means to evaluate basic performance. There is an analogy to a simulator tool test program though. There are about 12 simulation tools. How many FDD tools are there now?
- Phil Haves: (new topic) Will this produce a functional test procedure for generating the data? We probably need a simulation-based approach to make the data from the field more useful and to make interaction with the FDD tools dynamic. The simulation would be calibrated with the data.
- John House: Agree. I've neglected that . Others have suggested this also and we need as good simulator for this.
- Mike Brambley: This sounds like development of a standard rather than research. Has ASHRAE developed methods for test before (like ASTM does)? Should this work statement focus on developing an enabling test procedure that might be the foundation for development of a standard? ASHRAE standards involve consensus building. Research by itself can't produce a standard.

- George Kelly: ASHRAE could theoretically do this. This could be a straw man that could be flushed out more after it is done.
- Mike Brambley: Maybe data sets are inappropriate. Simulation is better to enable dynamic interaction between the FDD and the simulated device. Maybe this project should focus on "Development of simulation on which testing of FDD could be based."
- Jim Braun: Data is valuable, for example, you can use to calibrate models. Les Norford agreed on the value of data. Mike B. also agreed that data are needed to validate simulation.
- House, Braun, and Norford: Change emphasis in Task 3 to generating tools and data for the evaluation of FDD methods. This would be similar to phase 1 of the chiller FDD project.
- David Chassin: Data sets and simulations are better because they do not presuppose how the evaluation be done. In software development, we usually develop; tests after development of code.
- Haves: There needs to be a methodology defined. Are the performance criteria complete?
- John House: No, they are just a first cut.
- Phil Haves: The list of faults need to be informed by field experience and by commissioning/retro-commissioning experiences.
- Brambley: The list of faults should be evaluated by us as a group and pinned down for the contractor, otherwise there could be too much variation in bids for an ASHRAE project. Time is running out for this meeting, we need to define next step for this work statement.
- John House: We probably need to shift gears and write a new RTAR. This is a considerable change in scope from the current RTAR. It was approved but not prioritized. An informal vote by attendees was nearly unanimously in favor of proceeding in this way.
- George Kelly: The committee could in the future propose a standards committee on this topic.

Program

Brambley asked for any new ideas for program? There were none.

The subcommittee meeting was adjourned.

Appendix F.

TC4.11 Research Subcommittee meeting/Planning Session

Minutes

Honolulu, June 23, 2002 5:15-6:00 p.m.

Notes by: John House

Les: Summarized what was said today at the Section 4 Research Meeting…so what came out of it was a few action items. There will be a list server for TC 4 chairs to serve as a means as sharing info. There will be a method of sharing ATARs for the section (4). One more thing on the design side…initiate a special publication for design…that might be approached as a section 4 ATAR. Who in ASHRAE would support it? Issues of interactions with other TCs and broader issues of just how we define projects and how do we digest our research. We have research reports--are they the best way tell our results.

John House: One thing we have to do is come up with a long-range research plan. We could bring some prioritization on the ATARs that we have today. Organize where we think our priorities should be. Identify what are some of the gaps…look at areas that have FDD and which ones are lacking. Also, get feedback from industry …like public domain research. We have undertaken a fair amount of planning with our research..especially in these times of limited funds.

John House: We had two work statements; one approved and two returned. Last year we put in an ATAR on FDD methods of tools. Michael has his self-configuring controls work statement as an ATAR.

Les: We need to do the long term research plan…with Clay Nesler and Bob here because they come from private industry. Chiller Phase II can come off the list. The Field Performance System…stays there. It does not have to be one of the two that we put forward to ASHRAE. We talked about the refrigeration systems but the next steps would be more information gathering.

John House" Phil H. what is the status of the smart sensor systems?

Phil: Yes (it is dormant).

Les Is it worth keeping on?

Phil: One person pushes the project up…I am reluctant to put my effort into it. What are the needs? What are the better needs? I would like to see a way forward….

Les: So that we need ATARS for 3 and 5. 2 stays on the long range plan. 4, 6,7 are down below it. Clay can you help?

Bob: The whole building self-configuration…we are not really doing. Automated commissioning is really what I see that we are not doing.

Les: Online optimization is coming together, and we might want to join with TC 4.6.

Clay: What research could help the public sector? We tend to do more to get more global optimization. What really benefits the industry…we can do research to try to quantify the research. Try to make a case to see what was the value of the state of the art a couple years ago.

Phil: What do you mean?

Clay: Standard 55…there is a whole bunch of things that someone did 10 years ago that would be a good start. I am very familiar with the bottoms up.

Michael: Something that we talked about was Demand Responsiveness…we talked to the operators. The first thing that they said…there is a real need for some tools that allow a facility manager to get a handle of what loads he has. The Demand Sector of Big Buildings …we see a shift. The need here is to have tools to help the facility managers assess the value of Demand assets.

Les: What interests me is collaborating with other TCs about other work statements…I am not sure that much happened in that regard. I would like to come away with some means along the lines where we identify a half a dozen TCs and just share a List Server. It might encourage the TCs to share problems of interest.

Phil: We are trying to something on the section level. Section 4 is just a convenient umbrella. Not done in the past. Does not have to be by the section level…should not be inhibited by that.

Les: John House and I have to find people on our own committee and interface with people on other committees.

John House: Need to find someone to set up the List Server. TC 4.6 and TC 4.11 are natural.

Michael KM: We need some input from other TCs. Here is our list of ATARs to share the info. Can we converge? Info share exercise?

Les: The whole building diagnostics….Mike Brambley might have the only tool…What captures things left on at night…other stuff. I have not thought about the research in that area. Some uncovered research…perhaps.

John house: We are going to be doing more to coordinate with other TCs in Section 4. We will be sharing our ATRs and Long Range Research Plan…to get some informal feedback. Also, we need to inform people as a whole.

Les: Is the Handbook too early?

Jim Braun: I think so.

Phil: Are they looking for a chapter on Smart Building Systems?

Michael: How do we identify where we fit in?

John House: Done at 5:59pm.

Appendix G.

TC 4.11 Smart Building Systems

Research Plan and Activities

July 2000

Research Objectives: The long-term goal of TC 4.11 is to conduct research on topics that will lead to the development and application of "smart" building systems. "Smart" buildings of the future will take advantage of automation, communications, and data analysis technologies in order to operate in the most cost-effective manner. A smart building would most likely have fully integrated control of building services such as HVAC, fire, security, and transportation. Integrated systems would reduce initial costs and could be "supervised" so as to meet the primary objectives of comfort, safety, and performance at minimum operating cost. In addition, the integration of the hardware and software for operation and monitoring of equipment would lead to reductions in support staff needs and improved equipment reliability. Further cost reductions and reliability improvements would be possible through the integration of automated techniques for detection and diagnosis of equipment faults. Ultimately, "smart" building systems could facilitate the use of "remote" support staff that operates, monitors, and maintains a number of different buildings from a centralized location. At this higher level, a smart building might communicate and inter-operate with other smart buildings for the purpose of load aggregation and centralized control and with outside service providers, such as utilities, energy providers, aggregators, and newly developing companies providing fault detection, automated commissioning, optimization, and other innovative services. In addition to the savings in operating costs associated with "smart" buildings, other benefits include energy conservation and enhanced occupant safety and comfort.

Three subcommittees form the backbone of the TC's activities: Technology Development, Communications and Integration, and Testing and Evaluation. The Technology Development Subcommittee is concerned with research issues associated with the development of emerging smart building technologies such as automated commissioning, performance monitoring, fault detection and diagnosis, optimal maintenance scheduling, and optimal control. The primary outcome of research endorsed by this subcommittee is expected to be data and models that enable development of the technologies and comprehensive methods that are the basis of the technologies. The Communications and Integration Subcommittee is concerned with research issues associated with enabling the seamless interaction of smart building components and services. An important aspect of this work is to identify the information that is necessary to support smart building technologies, and to identify the requirements of communication protocols to support the exchange of this information between different building services, between buildings and utilities, between multiple buildings, with outside service providers, etc. The Testing and Evaluation Subcommittee is concerned with research issues associated with assessing the benefits (market

potential) and performance of smart building technologies. Research endorsed by this subcommittee is expected to result in data, metrics, methods, and tools/standards/guidelines for quantifying smart building system benefits and performance in a standardized manner, as well as findings from the actual application of these metrics, methods and tools.

Current TC 4.11 research includes projects in many of these areas. The evaluation of communication protocol requirements between utilities and energy management systems was addressed in the recently completed research project 1011-RP. Fault detection and diagnostics (FDD) is being considered for a number of different HVAC applications. Demonstration of the performance and benefits of current FDD approaches for air handling systems was performed as part of the recently completed research project 1020-RP. Tools for enabling the assessment of FDD methods for chillers are being developed in 1043-RP, while the development of on-line training techniques for model-based FDD methods is being carried out in 1139-RP for vapor compression equipment.

Revised 6/29/01, after Honolulu meeting

TC 4.11, Smart Building Systems

Research Plan and Activities

June 2002

Current Research Projects

None

2002-2003 Research Plan

Priority	Project	Contributors	Status

1	Field Performance Assessment of Package Equipment to Quantify the Need for Monitoring, FDD, and Continuous Commissioning	Todd Rossi Mark Breuker Jim Braun	RTAR rejected 9/00. Revised RTAR to be submitted by 8/01/01 as priority 1 RTAR for 2001. Revised RTAR approved 9/01. WS approved in Atlantic City 10-0-0 (CNV). WS submitted to RAC 5/15/02. Returned by RAC (Honolulu). WS approved in Honolulu subject to minor revisions
2	Tools for Evaluating FDD Methods for AHUs (Was "Method of Testing FDD Tools for AHUs")	John House Les Norford Mike Brambley Phil Haves Chariti Young Andrew Price	RTAR to be submitted by 8/01/01 as TC 4.11 priority 2 RTAR for 2001. RTAR approved 9/01. Draft WS exists. RTAR to be resubmitted 8/02 due to change in scope. Ranked priority 1 RTAR for 02-03.
3	Design and Demonstration of a Self-Configuration Concept for an HVAC Control System	Michael Kintner-Meyer	RTAR exists. Draft WS exists. RTAR to be submitted 8/02 as priority 2 RTAR for 02-03.
4	FDD for Supermarket Refrigeration	Todd Rossi	New research idea proposed in Honolulu.

5	Real-Time Optimal Control in a Distributed Environment	Jim Braun George Kelly	New research idea proposed in Honolulu.
6	Prototyping and Field Testing of Utility – Consumer Information Services	Michael Kintner-Meyer Marty Burns Chuck McParland	SSPC 135 has reviewed the WS and set up a utility/building interface working group. This group will work with TC 4.11 to identify research needs in this area.
7	Smart Sensor Systems for Reducing Bias Errors in the Measurement of Air Temperatures and Flows in Air-handling Units (Was "Development of Fault Detection and Diagnostics for Sensor Failures")	Arthur Dexter Phil Haves	Two page Issues Paper handed out by Phil Haves in Minneapolis. Revised two page write-up distributed by Arthur Dexter in Atlanta. Arthur will revise to focus on a particular application. Arthur has been asked to expand this to a WS for Atlantic City.
8	Resolving Discrepancies Between Multiple, Hierarchically-Related, Fault Detection and Diagnostic Systems	Mike Brambley Todd Rossi	Mike Brambley scaled back scope and distributed a revised WS in Atlanta. TES thought "looked good". Need to submit revised RTAR.
9	Development of Tools for Assessing the Value of Demand Response Assets	Michael Kintner-Meyer	New research idea proposed in Honolulu.
10	Whole-Building FDD	Les Norford	New research idea proposed in Honolulu.

Title: Field Performance Assessment of Packaged Equipment to Quantify the Benefits of Proper Service and Assessing the Long Term Need for Monitoring, FDD, and Continuous Commissioning Technology

TC/TG: TC 4.11 Smart Building Systems (Todd Rossi: rossi@acrx.com)

Research Category: Operation and Maintenance Tools

Research Classification: Basic and Applied

TC/TG Priority: 1 (2001-2002)

Estimated Cost and Duration: $150,000 ($125,000 ASHRAE + $25,000 DOE) and 24 months.

Other Interested TC/TGs: TC 9.9 (priority #2)

Expected Co-funding: $25,000 co-funding for this project promised by the U.S. Dept. of Energy.

Handbook Chapters Affected by Project Results: The results will be incorporated in few handbook chapter on Smart Building Systems.

State of the Art (Background):

Packaged HVAC equipment is the most common source of heating, air conditioning, and ventilation in small- and medium-size commercial buildings, including popular suburban retail shopping malls, supermarkets, and restaurants. Compared to large built up systems, packaged equipment are generally smaller and more numerous. Therefore, technicians spend less time servicing individual packaged units and the resultant field performance of this equipment may be much worse than that of their counterpart in built up systems.

Studies performed to date to assess the field performance of packaged equipment have been limited in scope and somewhat inconclusive. In 1992 and 1993, an HVAC/Refrigeration tune-up pilot program was implemented in Wisconsin to evaluate the effectiveness of HVAC and refrigeration tune-ups in saving energy and reducing peak demand in nine commercial buildings. The results varied widely, but energy savings of up to 15% were achieved in most buildings. Four major limitations to the study were cited including; (1) the number of sample points was small; (2) other factors affected building energy consumption; (3) HVAC performance enhancements improved comfort but did not always save energy; and (4) it was difficult to quantify the effect of particular maintenance activities without better controlled conditions or more sample points. A two-year study by the Electric Research Power Institute that was concluded in 1997 investigated the energy and demand impacts of maintenance on rooftop packaged heating and cooling equipment. Six long-term and 24 short-term sites were monitored. The short-term sites established the immediate impact of maintenance on savings and the long-term sites determined its persistence. The most prevalent problem was low refrigerant charge. No significant change in unit performance due to low charge, filter maintenance, or coil cleaning was observed. The study concluded that the cost of annual maintenance programs are unlikely to be offset by utility cost savings alone.

Other than these studies it is generally unknown how packaged equipment performs in the field. Laboratory studies of rooftop units show that performance is sensitive to typical faults observed in the field, yet these studies provide mixed results. An open and unbiased ASHRAE sponsored

research project provides opportunity for our engineering community to participate in a study to observe these effects in the field.

Advancement to the State of the Art (Justification):

This project takes additional steps toward quantifying the benefits of proper service in packaged equipment by assessing current performance of a statistically significant number of units in the field and documenting how the performance improves when a subset of these units are properly serviced. This approach will establish a more rigorous baseline than previous studies for the maximum possible benefits of proper servicing.

Packaged equipment performance has a direct impact on occupant comfort, indoor air quality and facility energy use in a large fraction of commercial buildings in the US. A recent DOE report indicates that rooftop and unitary A/C equipment consumes 1.03 out of a total of 1.66 quads (62%) of total energy consumed for cooling the current building stock of commercial buildings in the US. This research project will assess the level of improvement in energy efficiency that can be expected from proper servicing of packaged equipment, thereby establishing the need for diagnostic technology that can facilitate improved servicing of this type of equipment.

Justification and Value to ASHRAE:

> **Industry (i.e., building owners and facility managers) will benefit from this research by utilizing the results of the project to prioritize their maintenance and diagnostic efforts. The results will also help guide future efforts at ASHRAE, government and industry to develop technology and document its costs and benefits to help achieve widespread acceptance in the marketplace. Furthermore, the development of packaged equipment performance indices and experience with measuring, documenting, and reporting them will help researchers and product developers establish a unified approach to quantifying performance.**

Objective:

The objectives of this research project are to study and document:

1. **The actual field performances of 375 packaged HVAC units and compare them to industry norms or manufacturer's specifications for new equipment.**
2. **The implementation of diagnostic and proper service procedures and the resulting performance enhancement for at least 75 of the 375 units.**
3. **The need for monitoring, FDD, and continuous commissioning technology to address the long-term service needs of packaged equipment in the field.**

To preserve generality and anonymity and to prevent competition between unit manufacturers, units are to be classified generically

into categories including age, nominal capacity, refrigerant, type of expansion device, compressor technology, design EER, and electrical specifications. No make or model names or any other similar characteristics will be used to identify the units used in this study.

Bidders will be expected to collaborate with maintenance organizations such that this project will fund only the incremental costs of collecting and analyzing the data, not the cost of servicing.

Title: Tools for Evaluating Fault Detection and Diagnostic Methods for Air-handling Units

Research Category: Operation and Maintenance Tools

Research Classification: Basic and Applied Research

TC/TG Priority: #1 RTAR for 2002-2003; #2 priority overall on long-range research plan

Estimated Cost and Duration: $75,000 and 15 months

Other Interested TC/TGs:

Possible Co-funding Organizations:

Handbook Chapters Affected by Results of this Project: The results of this project and 1043-RP "Fault Detection and Diagnostic Requirements and Evaluation Tools for Chillers" are intended to lead to the development of a guideline or standard method of test for fault detection and diagnostic (FDD) tools.

State-of-the-Art (Background):

This RTAR describes a follow-on study to ASHRAE 1020-RP, "Demonstration of Fault Detection and Diagnostic Methods in a Real Building". The objective of 1020-RP was to demonstrate FDD methods in a real building, to assess the strengths and weaknesses of the methods investigated, and to provide guidance for future research in this area that will accelerate the development of FDD technology. The comparison included data for seven different faults collected during multiple seasons of the year. Both abrupt and degradation faults were considered. The data was collected at the Iowa Energy Center Energy Resource Station, a real building that serves as a test facility for energy-efficient technologies. The test procedure consisted of the following three steps:

1. **preliminary commissioning tests,**

2. **one-week of control tests in which faults were implemented and the researchers were told what faults were implemented (including severity), at what time they were implemented, and the duration they were sustained, and**

3. **one-week blind tests in which the researchers knew only that the faults considered during the control tests would be implemented at some time during that week.**

Step 1 was performed once, while steps 2 and 3 were performed once during summer conditions, again during winter conditions, and a final time during spring conditions. Both FDD methods proved capable of consistently detecting the faults, with a small number of exceptions. Fault diagnosis procedures were improved over the course of the tests and at the conclusion were also generally effective. However, diagnosis was made considerably easier than in what are likely to be typical conditions, due to the limited number of known faults, the known magnitude of the faults, and the excellent maintenance of building equipment and sensors.

The test procedure was then altered to evaluate the performance of the methods without the benefit of the control test data. The new test procedure was carried out on a different AHU and the researchers were not told what faults were implemented. The performance of the methods suffered with the removal of step 2. In particular, the ability to diagnose the implemented faults was poor.

ASHRAE 1020-RP illustrated how challenging it is to detect and diagnose faults in real buildings and, furthermore, how challenging it is to evaluate FDD tools. ASHRAE 1043-RP "Fault Detection and Diagnostic Requirements and Evaluation Tools for Chillers" produced a dynamic model of a centrifugal chiller that provides the capability for simulating fault-free and faulty chiller performance under real (steady-state and dynamic) operating conditions. 1043-RP also produced laboratory data for normal operation and a number of fault conditions (at various levels of severity) and at various load conditions. The data collected include both transient and steady state conditions. The models and data will be useful to developers of FDD tools for chillers when testing the performance of the tools. A similar set of testing tools is needed for AHUs.

Advancement to the State-of-the-Art:

Prototype FDD tools for AHUs have been in existence for several years. It is estimated that there are currently at least eight to 10 AHU FDD tools at various stages of development. At least one FDD tool is being marketed to building owners and operators, although none are currently implemented directly in energy management and control systems. The tools typically perform semi-automated FDD - detecting faults in equipment and control systems automatically, but requiring some level of human interaction to diagnose the source of the problem. Tools with these capabilities are ideally suited to operators responsible for large buildings, multiple buildings, and buildings with critical HVAC requirements (e.g., hospitals), commissioning providers, and other service providers who can use the tools to be more efficient in their duties.

Controls manufacturers are moving cautiously toward implementing FDD capabilities in their controllers, tempering their desire to

improve their products with the reality that the technology is still in its infancy. This conservative approach is understandable. The difficulty of the challenge of evaluating the performance of FDD tools has been noted previously. This work statement seeks to address this challenge by developing (if necessary) and validating simulation models that can assist FDD tool developers in the difficult task of evaluating the performance of their AHU FDD tools.

Justification and Value to ASHRAE:

Establishing accepted testing tools represents an important step in the development of new products. The simulation tool and supporting data developed in this project will provide developers of AHU FDD methods with resources that can be used to assess their performance. In doing so, commercialization of FDD technology will be expedited, thereby benefiting building owners, facility managers, operators, and occupants by helping ensure buildings are comfortable and utilize energy efficiently. This project, coupled with work performed in 1043-RP, could represent an important step toward the establishment of an ASHRAE guideline for testing FDD tools. A previous ASHRAE investment in 825-RP "A Standard Simulation Testbed for the Evaluation of Control Algorithms and Strategies" could be leveraged to reduce the effort required to develop a simulation tool for the project.

Objective:

The objective of this study is to develop or adapt a simulation model of an air-handling unit to produce fault-free and faulty data for a number of different types of faults and for a range of severities that can be used to assess the performance of AHU FDD methods. A further objective is to validate the simulation model using data from a laboratory or field site. Those data could be used to further test FDD methods for AHUs.

Title: Design and Demonstration of a Self-Configuration Concept for an HVAC Control System

Research Category: Design, Operation, and Maintenance Tools

Research Classification: Basic and Applied Research

TC/TG Priority: #2 RTAR for 2002-2003; #3 priority overall on long-range research plan

Estimated Cost and Duration: $100,000 and 24 months

Other Interested TC/TGs: TG 1.4, SSPC 135

Possible Co-funding Organizations: New York Energy Research and Development Authority

Handbook Chapters Affected by Results of this Project:

State-of-the-Art (Background):

The set-up and configuration of sophisticated HVAC control system in large buildings is difficult, time-intensive and error-prone. Thousands of sensors, controllers, and actuators control points need to be uniquely addressed and a binding list needs to be established specifying the connectivity between control devices. This task is labor intensive. It requires meticulous documentation of device addresses and data flow for all control points in the network in order to verify the proper operation of the control system for the building commissioning and for potential system modification later on. The large number of control points and cryptic names of the device addresses often lead to errors by binding controller inputs to wrong sensors. The trouble shooting of these errors are expensive and often remain unnoticed wasting valuable resources.

Faced with a similar challenge, the computer network industry has developed 'plug and play' concepts that support flexible and user-friendly set-up and configuration of personal computers, printers, and other devices to local area networks and the Internet. Technologies such as Sun Microsystems' Jini™ and Microsoft's Universal Plug and Play, have emerged over the last several years that provide concepts of self-configuration and automatic set-up procedures. These technologies enable end-users to install and connect new hardware and software to the computer networks and use distributed printing and other network services. These technologies reduce the time for network configuration and set-up and assure robust network operation by recognizing changes to the network as new devices are being installed and removed.

Over the last decade, the building automation industry with the leadership of ASHRAE has been successful in developing BACnet as communication standard so that information can be shared between devices from different vendors' products. The next logical step for the advancement of the HVAC controls industry is the development of self-configuring and plug and play technologies [ASHRAE 135-1995]. Today's state-of-art in building control systems falls far short of plug and play expectations. Plug and play capabilities cannot be achieved by standardizing the hardware specification and the communication protocol alone. In addition, the control devices need more intelligence to be able to support self-configuration that supports the interaction between the devices.

Advancement to the State-of-the-Art:

The development of self-configuring strategies for HVAC control systems is a natural and logical extension of the ASHRAE's efforts and leadership in promoting communication standards and the interoperability of intelligent HVAC control devices. It will advance the technology to the next level by greatly reducing the time for controls engineer to set-up the control system with multi-vendor products. It will provide an even greater benefit to the building operator and owner by assuring the consistent system configuration that can be easily re- or retro-commissioned to maintain high building system performance as the building undergoes many changes during is life-cycle. It would reduce the set-up cost for emerging and new fault detection and diagnostics products that require a data interface to the HVAC control system.

The industry is not likely to lead this effort because significant coordination efforts for the specification of self-configuration and plug and play standards among all stakeholders. It, therefore, necessary that a standards organization will need to step forward to demonstrate leadership that will advance the industry. ASHRAE is well positioned to fulfill this role through its leadership and commitment to develop the BACnet standard over the last decade.

Justification and Value to ASHRAE:

This research will initiate a new technology development direction that has the potential of significant impacts on the performance of and the energy consumed in buildings. If and when self-configuring HVAC control systems are matured as a commercially viable technology, they will significantly reduce system set-up cost while assure a high quality of service. They will enable user-friendly installation of fault detection and diagnostics tools and software and streamline and improve the re-commissioning process.

Objective:

The objectives of the work are:

1. **To develop a set of requirements for a self-configuration concept that are specific to the HVAC control system.**

2. **To design a self-configuration concept for HVAC control system and provide examples for the implementation of the self-configuration concept for a set of commonly used HVAC control subsystems (e.g., unitary controller, AHU controller, chiller controller).**

3. **To advice ASHRAE on what role it should or could take in advancing the concept to a technology.**

Reference:

ANSI/ASHRAE Standard 135-1995. BACnet - A Data Communication Protocol For Building Automation and Control Networks. ASHRAE, Atlanta, GA. 1995.

Title: Prototyping and Testing of Utility/Customer Information Services

TC/TG: TC 4.11 Smart Building Systems

Research Category: Operation and Maintenance Tools

Research Classification: Advanced Concepts

TC/TG Priority: 6

Estimated Cost and Duration:

Other Interested TC/TGs: TC 1.4, TC 1.5

Possible Co-funding Organizations:

Handbook Chapters Affected by Project Results:

State of the Art (Background):

Utilities and telecom companies have been experimenting with energy and non-energy information services for several years. Most of the experimentation has been performed in small-scale pilot programs with a relatively small number of participants. The majority of the technology implementations are centered around providing services such as automatic meter reading, outage detection, and

real-time-pricing (RTP) transmission. Only recently, spurred by the restructuring efforts in the electric power industry and the Telecommunication Act of 1996, has the industry has made bolder steps in marketing and implementation of information services.

On-site power generation from emergency generators has only recently been offered by technology companies and generator manufacturers. Web-based applications have emerged that provide gateway capabilities to interface commonly used EMCS. These systems can be bundled with other asset management services to provide full solutions to property management companies and ESCOs for load management, energy efficiency monitoring, alarm response, and diagnostics, as well as providing facility management functions such as asset inventory, facility maintenance scheduling and automated processing of work orders and procurement.

Direct load management applications are predominant in residential homes, where appliances such as air conditioners, pool pumps, and water heaters were cycled during peak times to reduce load. Most of the residential information services offered are Internet and cable TV services. However, given that a communication infrastructure is being developed by means of these applications, the same communication device transmitting entertainment information can be used to transmit energy information service in future applications.

By and large, utility trials have focused on implementing some targeted applications. Most of these were not concerned with the development of underlying communication infrastructures that would provide interoperability across network and communication technologies. Now the industry needs to complete the development of standards necessary to enable these services to a broad customer base including commercial, industrial and residential customers. Significant steps toward that end have already been done. The Electric Power Institute (EPRI) with its Utility Communication Architecture standardization efforts and, recently, ASHRAE with its support of research project 1011-RP are providing a systematic approach toward defining communication standards targeted at utility-customer communications.

Advancement to the State of the Art (Justification):

As a natural extension of ASHRAE research project 1011-RP, "Utility/Energy Management and Control System (EMCS) Communication Protocol Requirements", a two phase project for prototyping and field testing a set of selected information services defined in research project I011-RP is proposed. Phase I will focus on the prototyping and testing of information services under lab conditions in which the communicating parties are simulated. In Phase II, field trials will be proposed to implement and test the prototyped information services at 3-5 customer sites under real-world conditions. This RTAR describes Phase I only. Phase II will be defined in a later, separate RTAR.

The primary objectives of research project 1011-RP were: 1) to identify potential new information services that utilities or electricity suppliers are likely to offer to their customers, 2) to determine the communication and data requirements to establish these services, and 3) to develop data object models that support interoperability for the implementation of the services. This project will build on this

previous work. It will implement and test selected information services for commercial/industrial and residential applications in BACnet and CEBus environments. To expedite the prototyping and testing phase, the development is proposed to be performed in a simulated environment in which the communication between a utility/service provider and its customers is simulated in several networked computers under laboratory conditions. This work is specifically designed to verify the completeness, usability, of the set of data object models developed in 1011 - RP through a real implementation. By using the BACnet protocol for in-building communication it will build on and support the ASHRAE's standards work.

Justification and Value to ASHRAE:

Objective:

The implementation of a prototype of selected energy/information services will target the

following objectives:

1. **To verify the completeness of the data object and device models for selected energy and information services proposed under ASHRAE 1011-RP. The implementation will check the completeness and provide a basis for proposing enhancements/ modification to the object models.**

   2) To test the mapping of the data object models to BACnet and CEBus protocols, since the seamless bidirectional transport of information is imperative for robust communication.

3. **To provide experience with real implementation and provide the credibility and the refinement necessary to establish communication standards for energy/information services.**

4. **To assist the development of communication software necessary for the preparation of energy/information services to be studied in field trials during Phase II.**

Title: Smart sensor systems for reducing bias errors in the measurement of air temperatures and flows in air-handling units

TC/TG: TC4.11 Smart Building Systems (Arthur Dexter: arthur.dexter@eng.ox.ac.uk)

Research Category: Operation and Maintenance Tools

Research Classification: Basic and Applied

TC/TG Priority: 7

Estimated Cost and Duration: $100,000 and 18 months

Other Interested TGs/TCs: TC 1.4; TC 4.6

Possible Co-funding Organizations:

Handbook Chapters Affected by Project Results:

State of the Art (Background):

The presence of significant measurement errors is one of the main barriers to the automatic detection of many important faults in air-conditioning systems. For example, the air temperature difference across a coil may be more sensitive to the offset errors associated with the measurement of the on-coil air temperature than it is to fouling of the coil.

The accurate measurement of the temperature and velocity of the air flowing down a large duct is extremely difficult when there are significant variations in the temperature and velocity over the cross-section or radiant energy gains from surrounding surfaces. Current sensors are either very inaccurate or very expensive. Even currently available commercial averaging sensors for measuring air temperature and air flow rates can produce large errors in certain locations (for example, immediately downstream of a mixing-box or heat-exchanger).

Advance to the State of the Art (Justification):

There are two basic causes of the errors (i) faults associated with incorrect installation or calibration of the sensor (ii) the use of a single sensor to measure average value of a spatially distributed variable. Sensor faults can be eliminated during commissioning but the errors arising from spatial variations are more difficult to eliminate, particularly if the spatial distribution changes with operating conditions. Here the problem is not the accuracy or precision of the sensor itself but estimation bias.

The measurement accuracy can be improved without increasing the cost of the sensors by using techniques such as data fusion, based on Kalman filters or fuzzy logic, or inferential measurement schemes.

Justification and Value to ASHRAE:

Objectives:

The objectives of this research are to:

1. **determine the magnitudes and causes of the bias errors associated with current sensors that are used to measure duct air temperature and flow rate**
2. **investigate ways of automatically detecting and identifying the magnitude of these errors**
3. **develop techniques for automatically compensating for these errors**
4. **demonstrate the practical benefits of such techniques in fault detection and diagnosis**

The work would involve:

1. **examining the literature and performing experiments to obtain a better understanding of the relationship between the output of the sensor and the quantity to be estimated, under different operating conditions.**
2. **investigating ways of generating an estimate of the uncertainty associated with the output of the sensor**
3. **identifying other information (for example, auxiliary or additional measurements and control signals) that could be used to reduce the uncertainties. For example, another estimate of the air-flow rate is related to the fan control signal; the temperature distribution downstream of the mixing-box is related to the control signal to the dampers; the radiant energy gain experienced by a sensor located close to a coil is related to the coil's valve control signal.**
4. **quantifying the uncertainties associated with the these information.**
5. **developing a smart sensor system that is capable of more accurate measurement.**
6. **assessing the benefits of using such sensors with fault detection and diagnosis schemes by experiments in a real building or laboratory test rig.**

References:

Carling, P. and Isakson, P. 1999. Temperature measurement accuracy in an air-handling unit mixing box. The 3rd International Symposium on HVAC, ISHVAC '99. Shenzhen, China.

Kelso, R. M., Marshall, P. H. and Baker, A. J. 2000. A CFD study of airflow in a mixing-box, Proc. CIBSE/ASHRAE conference, Dublin, Ireland.

Robinson, K. D. 1999. Mixing effectiveness of AHU combination mixing-box /filter-box with and without filters, Trans. ASHRAE.

Wang, S. W., and Wang, J. B. 1999. Law-Based Sensor Fault Diagnosis and Validation for Building Air-conditioning Systems, International Journal of HVAC&R Research, 5(4), pp.353-378.

Title: Resolving Discrepancies Between Multiple, Hierarchically-Related, Fault Detection, and Diagnostic (FDD) Systems

TC/TG: TC 4.11 Smart Building Systems

Research Category: Operation and Maintenance Tools

Research Classification: Basic and Applied

TC/TG Priority: 8

Estimated Cost and Duration:

Other Interested TC/TGs: TC 4.6

Possible Co-funding Organizations:

Handbook Chapters Affected by Project Results:

State of the Art (Background):

Large systems, including buildings, can be represented in a hierarchical structure where the entire system is divided into sub-systems, which are in turn divided into sub-sub-systems. Fault detection and diagnostic (FDD) methods or software modules can operate on one or more levels or at different levels throughout this hierarchical structure. Such systems promise to provide the greatest benefits for large systems (e.g., all the HVAC equipment in a 40 story building) that need the hierarchical structure to divide the system into

manageable components, but the hierarchical structure could be applied to smaller buildings and may be of value in implementing the diagnostic processes themselves.

When FDD methods operate on hierarchically-related entities, they may produce results that contradict one another. Subsystems have interactions (consider, for example, the chilled water temperature that is produced by the chiller and used by cooling coils). This, along with uncertainty in measured conditions, creates the potential for overlapping and conflicting results when FDD methods are applied to different individual entities at different levels or subsystems in the hierarchy. For example, the chiller FDD might call for a warmer chilled water temperature while some of the cooling coils it serves call for a lower chilled water temperature. For a building operator to use advice from these distributed, independent FDD systems, some coordination of their results or resolution of conflicts is needed. Conflict resolution might be done manually by the FDD user (e.g., building operator), automatically at a supervisory level (e.g., on the operator workstation), or automatically at distributed points in the FDD system.

This work statement focuses on resolving conflicts between FDD solutions that are likely to utilize distributed computing (i.e., processing takes place at multiple locations distributed throughout the building and/or control system), but it also applies to FDD methods implemented as separate processes or software modules run on the same computer.

Advancement to the State of the Art (Justification):

Fault detection and diagnostic (FDD) techniques are emerging from research and are beginning to be tested in real buildings. Many of these techniques focus on specific HVAC subsystems or components of them; others operate at the whole-building level to identify performance anomalies and identify subsystems causing the anomalies. At the same time, control functions are becoming more distributed with much control processing (computing) taking place at the device or subsystem level, rather than at a central (building-level) location. This provides opportunities for the use of distributed FDD in conjunction with distributed control, yet creates the need to coordinate and resolve conflicts between diagnostic results produced by different FDD systems. This research project responds to that need by providing information that will be needed by the HVAC professions to successfully apply distributed FDD in buildings by developing and evaluating methods for resolving conflicts between FDD systems.

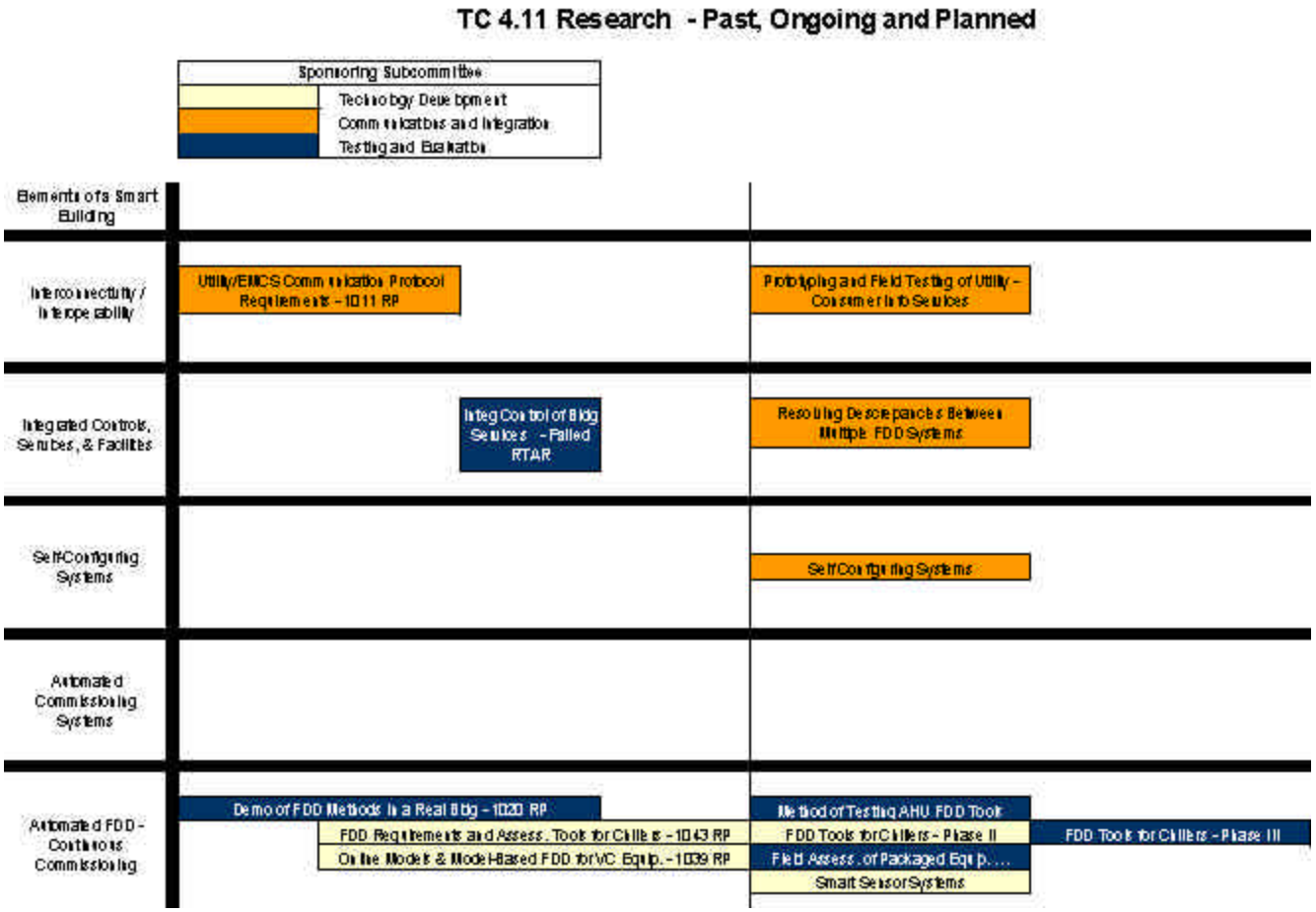
Justification and Value to ASHRAE:

Objective:

The objective of this research is to investigate how results from FDD methods applied separately to distributed and hierarchically-related HVAC subsystems and equipment can overlap and potentially conflict with one another. Then, based on this

investigation, identify, develop and validate, test and evaluation methods for resolving these conflicts. The final results of this research will be a well-documented evaluation of methods for overcoming conflicts generated by FDD methods or software along with guidance regarding circumstances under which to use each adequately-performing method. The final document shall include detailed examples of method applications.

TC 4.11 Smart Building Systems Research: Past, Ongoing and Planned



Appendix H.

List of Subcommittee Attendees

Atlantic City: January 1, 2002

	Technology Development	Communications & Integration	Testing & Evaluation	Research
Voting Members				
Les Norford, Chair (V)	x	x	x	x
John House, Vice Chair, Research Subc (V)	x	x	x	x
Michael Kintner-Meyer, Communications and Integration Subc (V)	x	x	x	x
Todd Rossi, Fault Detection Diagnostics Subc, (V)	x	x	x	x
Natascha Castro, Secretary, Web Master (V)	x		x	x
Steve Blanc, (V)	x	x	x	x
Barry Bridges (V)	x			x

James W. Gartner (V)		x		
Rich Hackner, (V)	x	x	x	x
John Seem, (V)				
Mike Brambly, Testing and Evaluation Subc, CM	x	x	x	x
Phil Haves, (V)	x	x	x	x
Agami Reddy, CM	x	x	x	x
John Mitchell , CM	x		x	x
Carlos Haiad, (V)				
Srinivas Katipamula (V)				
Arthur Dexter, International member (V)	x		x	x

Non-Voting Members

Michael Brandemuehl, CM

Thomas Engbring, CM

Brian Kammers, CM

Ron Nelson, CM

Barry Reardon, CM

Dave Branson, CM

James Braun, CM x

Hung Mahn Pham, CM

Robert Old, CM

George Kelly, CM				
Carol Lomonaco, , CM Program Subc				
Charles Culp, CM				
David Kahn, CM				
Osman Ahmed				
Peter Armstrong	x	x	x	x
Jim Butler	x	x		
Peter Gruber				
Keith Temple				
Peng Xu	x			
Don Aymann				
Jon Douglas	x	x	x	x
Tim Salsbury	x	x	x	x
Par Carling	x	x	x	x
Rodney Martin	x	x	x	x
Virgil Seribo		x		
Hofu Kiu	x			
Gene Strehlow			x	
Song Zhang		x		
David Shipley			x	

Kirstin Heinemeier			x	
Paul Reimer				
Glenn Remington				
Zach Obert				
Curtis Klaassen				
Marty Burns	x	x	x	x
Cliff Federspiel				
Richard Kelso				x
Pornsak Songkakul				
Jean Christophe Visier			x	x
Jonathan Wright	x			